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MAR 13 1975

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Snow Accumulation and Melt Along Borders
of a Strip Cut in New MexicoHoward L. Gary¹

Snowfall amounts were similar along the sunny and shady borders of an east-west oriented clearcut strip. Maximum snow accumulation was greater along both borders than in the adjacent forest. Periodic melting along the sunny border reduced the snowpack, but winter melt losses were somewhat balanced by melt crusts which prevented blowing snow. Snow disappeared 5 to 6 weeks earlier along the sunny border than along the shady border or forest interior. Melt rates along the shady border were 30 to 40 percent greater than those observed in the forest interior, but times of complete melt were the same.

Keywords: Clearcutting, snowmelt, watershed management, water yield improvement.

Most studies in forested snow zones have shown greater quantities of snow in small openings and narrow strip cuttings than under forest cover. Increased snow accumulation is not caused wholly by decreased interception loss, but rather by redistribution of snow and other factors (Anderson and Gleason 1959, Gary 1974, Hoover and Leaf 1967). Thus, the usually greater quantity of snow in clearings must be balanced against the deficit inside the adjacent forest when evaluating the effect of timber cutting practices on snow accumulation. Snow distribution and melt across openings and in clearings are likewise highly variable, and additional information is needed if we are to fully evaluate the effectiveness of strip cutting and/or patch-cuts for snowpack management.

This Note reports a 2-year survey of snow accumulation and melt along the sunny and shady borders of an east-west oriented powerline right-of-way through an Engelmann spruce (*Picea engelmanni* Parry) stand. The clearcut strip extended across a south slope, and was generally perpendicular to the hour

angles with maximum solar energy. The strip cut, except for length, was similar to the first phase of the proposed wall-and-step forest that would provide the maximum amount of shade over logged areas (Anderson 1956).

Study Area

The study area was about 16 miles northeast of Santa Fe, New Mexico, and one-third mile north of the headquarters of the Santa Fe Basin Winter Sports Area. The general slope aspect was southwesterly, but the study area aspect was south facing. Forest cover was dense Engelmann spruce 55 to 60 feet tall. The study plots were 10,300 feet above m.s.l., one-half mile from an 11,500-foot ridge line. Slopes near the study plots ranged from 15 to 20 percent. Prevailing winds were southwesterly.

Instrumentation and Methods

About 1960, a 60-foot-wide strip (one tree-height wide) was clearcut through the area for a powerline right-of-way. In 1967, six study plots were established along the sunny and shady borders of an east-west segment of the clearcut strip, three along each border. Plots were about 20 feet long with a 10-foot buffer zone between.

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Two rows of 10 snow depth markers were located 8 and 14 feet from the forest borders. Depth markers (5.5-foot metal rods, 1/4-inch diameter) were spaced about 2 feet apart, and were color coded at 1-inch intervals. Standard rain-gage cans were located at each end of the study borders on both sides of the clearing, and a recording rain gage was placed in the center of the study area. Instrument shelters housing a recording thermograph were also located on both sides of the clearing. Five depth markers spaced 5 feet apart were placed about 40 feet (about two-thirds tree height) inside the adjacent forest along both borders.

Weekly snow depth and snow water equivalent measurements were begun in December and continued until the end of the melt season for a 2-year period. Rain gages and thermographs were also serviced weekly. Starting in January, during one year, a 1-foot-square by 1/2-inch-thick board painted white, covered with white flannel and equipped with a depth marker, was placed near the center of each plot. The snowboards provided an additional index of depth and water equivalent of new snowfall during the previous week.

To characterize the borders, amounts of sun and/or shade were estimated weekly during one winter season. An average value for shade along each border was computed after estimating the presence or absence of shade around each of the 60 depth markers, usually at noon and again at 1 p.m. A depth marker was considered as shaded when an imaginary circle (1-foot diameter) around it was more than 50 percent covered by dense or diffuse shade.

Amounts of evaporation from the snow surface along the sunny and shady borders were determined for several 15-hour night and 8-hour day periods during one year from January to April. Five undisturbed snow cores were taken from each border and placed in circular 6-inch-diameter, 5-inch-deep clear plastic pans with false bottoms (West 1962). The pans of snow were weighed before and after varying exposure times at the snow surface, and amount of evaporation was then computed.

Border Climate

The amounts of shade along the borders near solar noon for selected times during 1968 were:

	Sunny border	Shady border
	(Percent shade)	
January 24	2	75
February 21	0	76
March 25	0	60
April 25	0	54

The greatest climatic difference between the plots was apparently the higher amount of direct insolation received along the sunny border (Geiger 1957). During cloudy and overcast days, there was probably little difference in irradiation along the borders. Also, after heat losses during clear nights, both borders probably had similar heat balances by sunrise.

The air temperatures gave a relative measure of the insolation differences (table 1). The monthly maximum air temperatures were 7° to 9°F above freezing along the sunny border, and snow melted periodically through the winter. Ice chunks and lenses and a persistent ice layer at the ground surface were always encountered when measuring water content of the snow along the sunny border, but not along the shady border. Number of days with maximum air temperatures 32°F or above were:

	Sunny border	Shady border
January	22	7
February	23	9
March	25	15

Minimum air temperatures were similar along both borders; they were below freezing every night from January through March.

Table 1.--Mean maximum and minimum air temperatures (°F) for the sunny and shade border plots (1967-68)

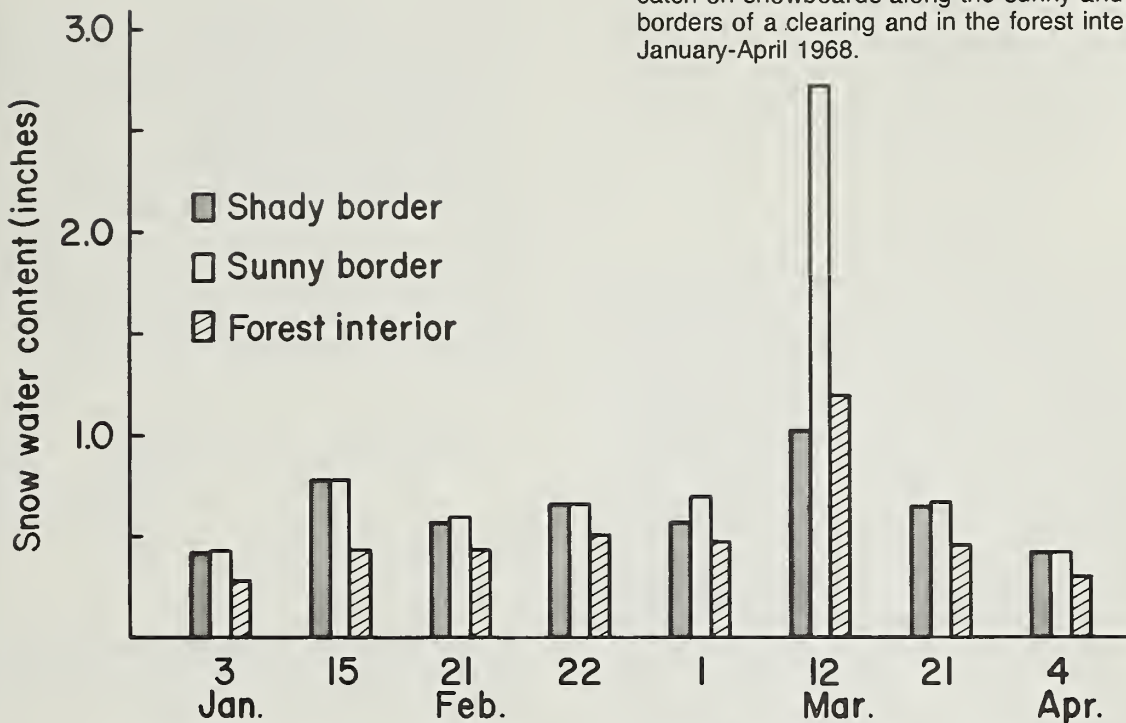
Month	Sunny border		Shady border	
	Maximum	Minimum	Maximum	Minimum
December	30.7	10.7	24.0	10.2
January	36.5	13.6	27.5	13.6
February	37.4	14.8	29.4	15.7
March	38.6	15.2	31.2	15.7
April	40.7	18.8	34.6	18.7
May	52.8	28.1	47.5	28.3

Border Effects on Snow Catch

The weekly snow catch on the snowboards was about the same for the sunny and shady borders (fig. 1). The snowboards apparently measured snowfall more accurately than the rain gages. During big storms, the gages were usually bridged over with snow, and did not measure total snowfall.

Sunny and shady borders were about equally efficient for trapping and holding snow during storms as well as during post-storm periods (fig. 1). The one exception was during the week ending March 12, 1968. A strongly bonded 1-inch ice

Figure 1.—Weekly measurements of average snow catch on snowboards along the sunny and shady borders of a clearing and in the forest interior for January-April 1968.



crust was present along the sunny border on March 12, but not along the shady border where temperatures remained below freezing. Strong winds on March 10 and 11 redistributed much of the uncrusted snow from along the shady border.

During the relatively common windstorms in the spring, when ice crusts are not present, new snow is blown from both the sunny and shady border plots and redistributed into the forest interiors. For practical purposes and under conditions of the study, it was apparent that initial snowfall amounts were similar along the sunny and shady borders.

Border Effects on Snow Evaporation

Weight loss from snow-filled pans was determined once each week for 12 weeks during the period January 8 to April 18, 1969. Average daily snow evaporation amounts were:

	Sunny border (Inches)	Shady border
Day	0.0133	0.0065
Night	.0009	.0011

Water loss by evaporation along the sunny border was relatively small during the daylight hours, but averaged twice the amount observed

along the shady border. Losses for the night periods were reduced by condensation on the snow-filled pans.

The measured losses were in general agreement with values reported for most snowpack timber zones in the western States. West (1959) reported annual snow-evaporation losses varied between 1.0 and 1.5 inches in a small forest opening about one-half tree height wide, and 0.4 to 1.0 inch in a forest of 70 percent density. Annual evaporation losses along the shady border in the present study area would not likely exceed the values observed in West's small opening.

Evaporation losses in the present study were probably reduced to some minimum value during storm periods. For the 1969 study period, an estimate of cloudy weather based on number of days with snow greater than 0.02 inch water equivalent was:

	Precipitation > 0.02 inch (Days)
January	14
February	11
March	19
April	9

While there may be large relative differences by slope, aspect, size of openings, and density of the forest, evaporation losses appear to be a

small percentage of the total snowfall. It is unlikely that evaporation differences between the sunny and shady borders were large enough to account for more than a small fraction of the large difference observed in snow accumulation along the borders of the clearing.

Snow Storage and Melt

The patterns of snow accumulation and melt along the borders of the strip-cut and in the forest interior were nearly identical for the 2 years of study (fig. 2). Through most of the snow accumulation season, the shaded border plots contained 1 to 1.5 inches more snow water content than the sunny border plots. The difference was apparently the result of periodic melting through the winter, since snow catch and evaporation were about the same along both borders. During one week in March in both years, the sunny border plots either equaled or exceeded snow accumulation along the shady border. These anomalies were apparently the result of high winds blowing away uncrusted snow along the shady borders.

Near the time of maximum snow accumulation along the sunny border (about March 12 both years), the border plots on the average contained about 27 percent more snow during 1968 and about 40 percent more during 1969 than the forest interior plots. The clearing apparently affected the distribution of snow, but the total amount of snow was probably unchanged (Hoover and Leaf 1967). It is evident from similar studies that increased quantities of snow in openings and in clearings must be balanced against decreased quantities in the adjacent forest in order to evaluate clearing effects on snow accumulation (Gary 1974).

Spring snowmelt along the sunny border was completed in roughly 1 month (from March 12 to April 17 in 1968 and by April 10 in 1969) (fig. 3). The average melt rate was 0.28 inch per day in 1968, 0.36 inch per day in 1969. The shady border showed some of the characteristics of the forest interior in prolonging snowmelt. When snowmelt was nearly complete along the sunny border (April 4, 1968), the amount of snow remaining along the shady border was 95 percent of the assumed maximum accumulation. In 1969, about 86 percent of the assumed maximum snowpack was present at the time of complete melt (March 26) along the sunny border. Similar results of shading were also observed by Gary and Coltharp (1967) at an elevation of 11,500 feet in the same watershed. They reported that, when snowmelt was completed on a south-facing aspect of a large open burn, 83 per-

cent of the maximum snowpack was present under an adjacent and similarly oriented old-growth spruce-fir forest. On a north-facing aspect, 93 percent of the maximum snowpack was present under the spruce-fir forest at the time of complete melt on the burn.

Complete melt along the shady border and in the forest interior was 5 to 6 weeks later than along the sunny border. The shady border had more snow, but the time of complete melt was about the same for the shady border and forest interior. Average daily snowmelt rates along the shady border and in the forest interior from the time of maximum snowpack were:

Period of melt	Shady border (Inches of water)	Forest interior
April 4 to May 28, 1968	0.188	0.131
April 17 to May 15, 1969	.443	.268

Average daily melt rates along the shaded border ranged from 30 to 40 percent greater than melt rates in the forest interior.

Summary and Conclusions

The sunny and shady borders along a long clearcut strip received similar amounts of snow each storm. Although periodic winter melting along the sunny border reduced the amount of water stored there, the melting loss along the sunny border was eventually balanced by the effect of melt crusts which reduced the amount of blowing snow.

At the time of maximum snowpack, the greatest quantities of snow were along the sunny and shady borders of the clearcut strip. Based on evidence from other studies, the higher snow catch in the clearing was the result of snow redistribution from the adjacent forest interiors. Small patch-cuts no greater than five to eight tree-heights in diameter will probably accumulate maximum quantities of snow (Hoover 1969). Shorter clearings would greatly reduce windspeeds and intensity of blowing snow events.

Melt rates were accelerated along both the sunny and shady borders of the clearing. It is most probable that snowmelt rates in clearings one tree-height wide or larger will be significantly greater than melt rates under surrounding forest cover. The significantly deeper snow along the shady border melted about the same time as the shallower snow in the adjacent forest.

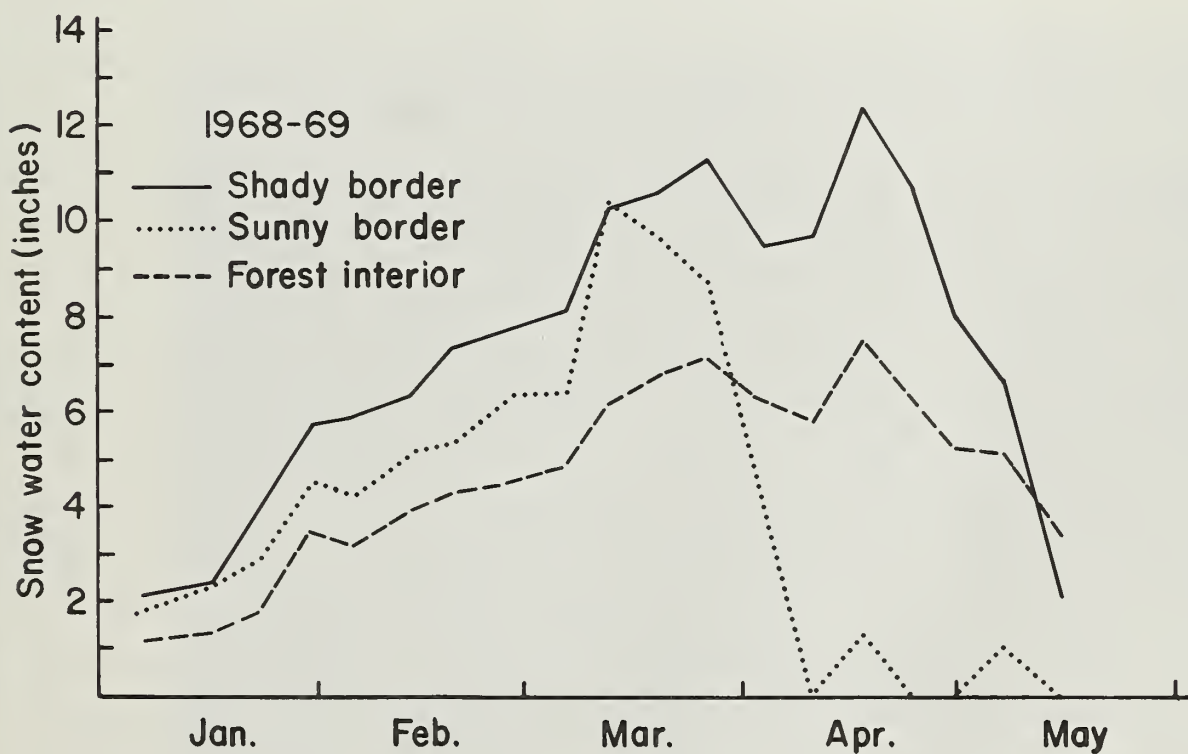
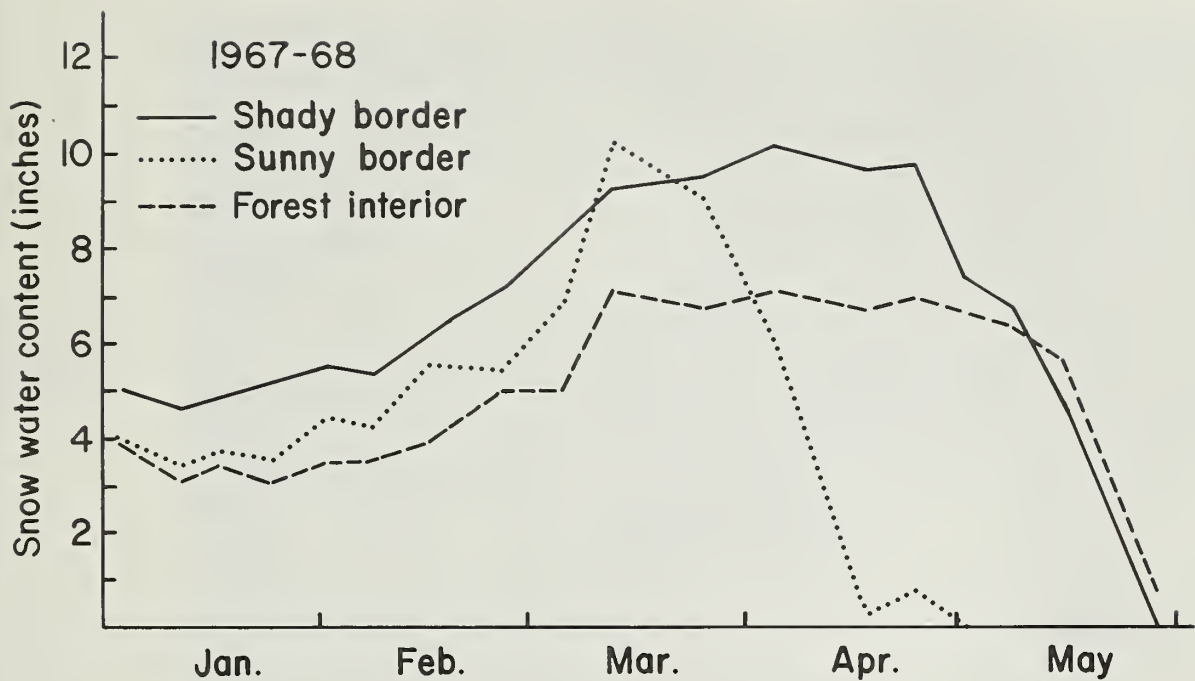


Figure 2.—Snow accumulation and melt along the sunny and shady borders of the clearing and in the adjacent forest interior.



April 17
Sunny



May 1
Sunny

April 17
Shady



May 1
Shady



Figure 3.—Progress of snowmelt along the sunny and shady borders of the clearcut strip during the spring of 1968.

More and earlier water yield should result from forest harvesting in narrow and short clearcut strips and/or small patch-cuts because of reduced transpiration losses, a greater unit-area concentration of snowmelt water, and a greater year-to-year carryover of soil moisture.

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